Deutsches Institut für Bautechnik

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Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment

ETA-23/0978 of 29 April 2024

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Halfen Stud Connector
Product family to which the construction product belongs	Stud connectors for anchoring in reinforced concrete members as well as for connecting steel members with reinforced concrete members
Manufacturer	Leviat GmbH Liebigstraße 14 40764 Langenfeld
Manufacturing plant	Leviat Manufacturing Plants
This European Technical Assessment contains	33 pages including 4 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 160202-00-0301

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Specific Part

1 Technical description of the product

Halfen Stud Connector is a load-bearing anchoring and connecting element for use in end supports of reinforced beams, slabs or walls, in corbels, in exterior beam-column-joints or for bolted end-plate connections in reinforced concrete structures.

The product description is given in Annex A.

The characteristic material values, dimensions and tolerances of the anchoring and connecting element Halfen Stud Connector not indicated in Annexes A1 to A10 shall correspond to the respective values laid down in the technical documentation[1] of this European Technical Assessment.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The performances given in Section 3 are only valid if the anchoring and connecting element Halfen Stud Connector is used in compliance with the specifications and conditions given in Annex B.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the anchoring and connecting element Halfen Stud Connector of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Resistance to static or quasi-static loading	
Tensile strength of reinforcing bar	see Annex C1 and C2
Tensile strength of mechanical splice of reinforcing bars	see Annex C1
Tensile strength of mechanical splice of reinforcing bar and structural steelwork socket	see Annex C2
Combined tensile and shear strength of structural steelwork socket	see Annex C3
Influential factors	see Annex C1 and C2
Resistance under fatigue loading	
Fatigue strength for $N = 2 \cdot 10^6$ load cycles	see Annex C1 and C2
Fatigue strength for S-N curve with k_1 and k_2 according to EN 1992-1-1	No performance assessed
Fatigue strength for S-N curve with specific k_1 and k_2	see Annex C1 and C2

[1] The technical documentation of this European technical assessment is deposited at the Deutsches Institut für Bautechnik and, as far as relevant for the tasks of the approved bodies involved in the attestation of conformity procedure, is handed over to the approved bodies.

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with EAD 160202-00-0301 the applicable European legal act is: 2000/606/EC.

The system to be applied is: 1+

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

The following standards and Technical Assessments/Reports are referred to in this European Technical Assessment:

- EN 206:2013+A2:2021 — Concrete - Specification, performance, production and conformity
- EN 1992-1-1:2004 + AC:2010 + A1:2014 — Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
- EN 1993-1-1:2005 + AC:2009 — Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
- EN 1993-1-4:2006 + A2:2020 — Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
- EN 1993-1-8:2005 + AC:2009 — Eurocode 3: Design of steel structures - Part 1-8: Design of joints
- EN 1993-1-9:2005 + AC:2009 — Eurocode 3: Design of steel structures - Part 1-9: Fatigue
- EN 10025-2:2019 — Hot rolled products for structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
- EN 10088-2:2014 — Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
- EN 10088-3:2014 — Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes
- EN 10277:2018 — Bright steel products – Technical delivery conditions
- EN 13501-1:2018 — Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests

– EN ISO 898-1:2013	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1:2013)
– EN ISO 1461:2022	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2022)
– EN ISO 3506-1:2020	Fasteners - Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs with specified grades and property classes (ISO 3506-1:2020)
– EN ISO 3506-2:2020	Fasteners - Mechanical properties of corrosion-resistant stainless steel fasteners - Part 2: Nuts with specified grades and property classes (ISO 3506-2:2020)
– EN ISO 4042:2022	Fasteners - Electroplated coating systems (ISO 4042:2022)
– EN ISO 7089:2000	Plain washers - Normal series, Product grade A (ISO 7089:2000)
– EN ISO 7093-1:2000	Plain washers - Large series - Part 1: Product grade A (ISO 7093-1:2000)
– EN ISO 10684:2004/AC:2009	Fasteners - Hot dip galvanized coatings (ISO 10684:2004 + Cor. 1:2008)
– EN ISO 17660-1:2006	Welding – Welding of reinforcing steel – Part 1: Load-bearing welded joints (ISO 17660-1:2006)
– EOTA EAD 160202-00-0301	Stud connectors for anchoring in reinforced concrete members as well as for connecting steel members with reinforced concrete members
– EOTA TR 081:2023	Design methods for verification of load-bearing capacity of stud connectors for anchoring in reinforced concrete members
– ETA-21/0800 of December 6, 2021	HALFEN HBS-05 Bewehrungsschraubanschluss

Issued in Berlin on 29 April 2024 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

beglaubigt:
Kisan

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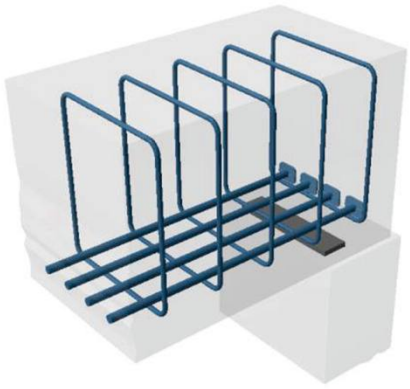
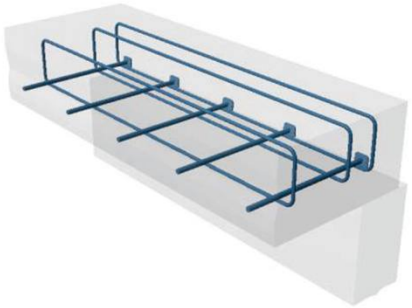
A.1 Headed rebars

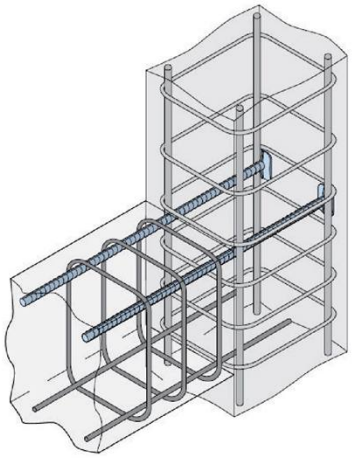
Beam with
Halfen Stud Connector type HSC-H



Slab with
Halfen Stud Connector type HSC-H



Exterior beam-column joint with
Halfen Stud Connector type HSC-H



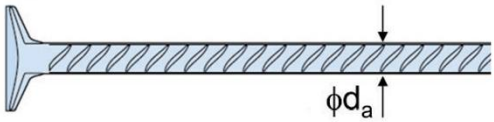


Fig. A1: Halfen Stud Connector type HSC-H

Headed rebars made from reinforcing steel for anchoring of longitudinal tension and bending reinforcement at end supports or joints

Halfen Stud Connector	Annex A1
Product description Product, installed conditions with headed rebars “Halfen Stud Connector HSC“	

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Corbel with
Halfen Stud Connector type HSC-HD

Double-sided corbel with
Halfen Stud Connector type HSC-HD

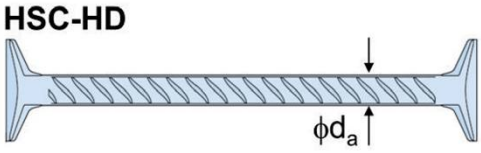

Fig. A2: Halfen Stud Connector type HSC-HD

Headed reinforcement made from reinforcing steel for anchorage of longitudinal tension reinforcement in corbels and columns

Halfen Stud Connector	Annex A2
Product description Product, installed conditions with headed rebars “Halfen Stud Connector HSC“	

Corbel with
Halfen Stud Connector type HSC-S and HSC-A

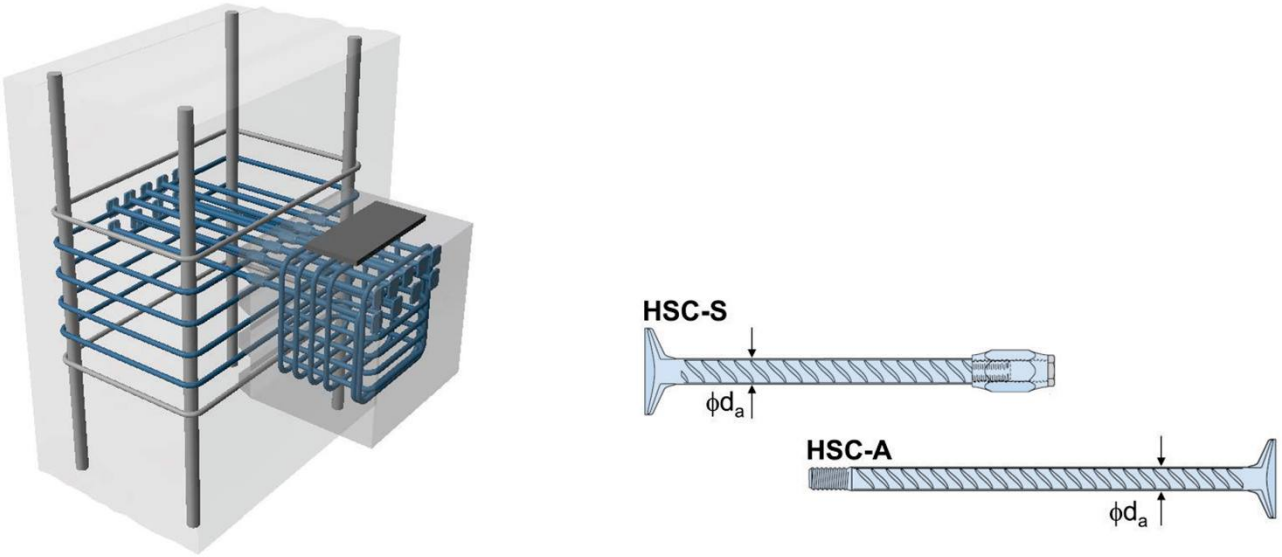

Fig. A3: Halfen Stud Connector type HSC-S and HSC-A
Headed rebars made from reinforcing steel for anchoring of longitudinal tensions reinforcement in corbels and columns cast at different times, mechanical splice of reinforcement bars, construction joint to the column, separate detailing of splitting reinforcement in corbel and column

Double-sided corbel with
Halfen Stud Connector type HSC-SD and HSC-A

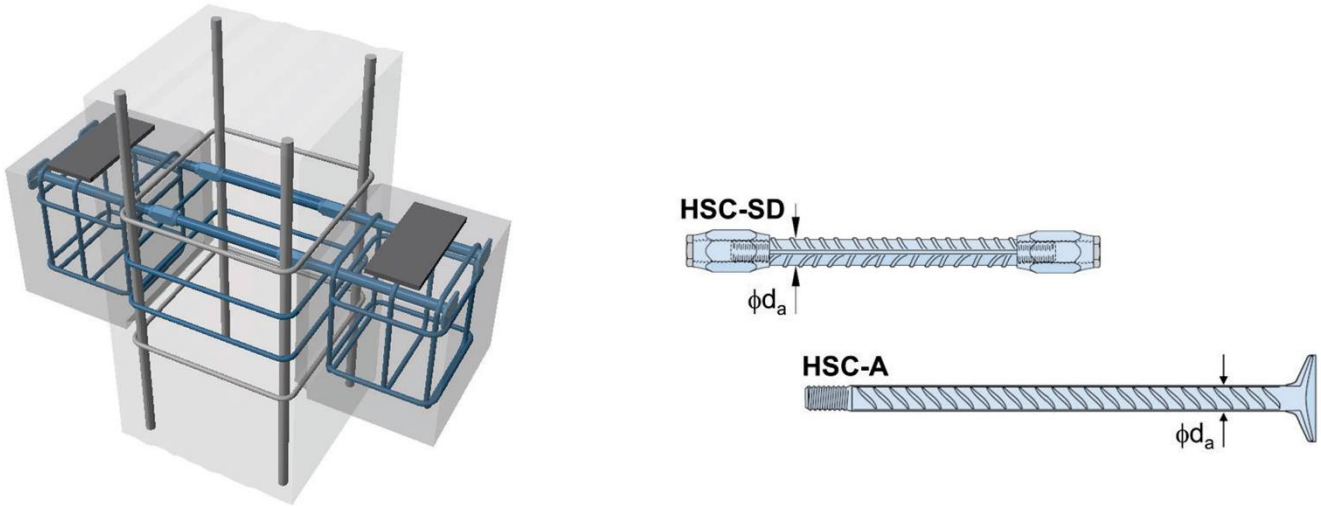

Fig. A4: Halfen Stud Connector type HSC-SD and HSC-A
Headed rebars made from reinforcing steel for anchoring of longitudinal tensions reinforcement in corbels and columns cast at different times, mechanical splice of reinforcement bars, construction joint to the column, separate detailing of splitting reinforcement in corbel and column

Halfen Stud Connector	Annex A3
Product description Product, installed conditions with headed rebars “Halfen Stud Connector HSC“	

A.2 Structural steelwork socket bars

Bolted end-plate connection with
Halfen Stud Connector type HSC-B SH

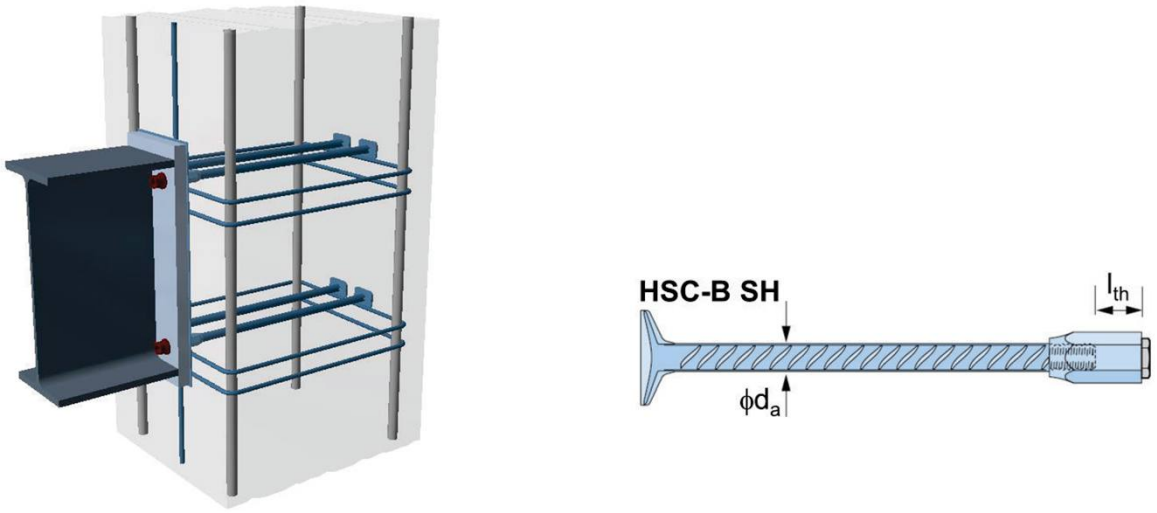

Fig. A5: Halfen Stud Connector type HSC-B SH

Structural steelwork socket for mechanical connection with fastener, socket bars with anchor head made from reinforcing steel for anchorage the connected loads in reinforced concrete structures

Bolted end-plate connection with
Halfen Stud Connector type HSC-B S

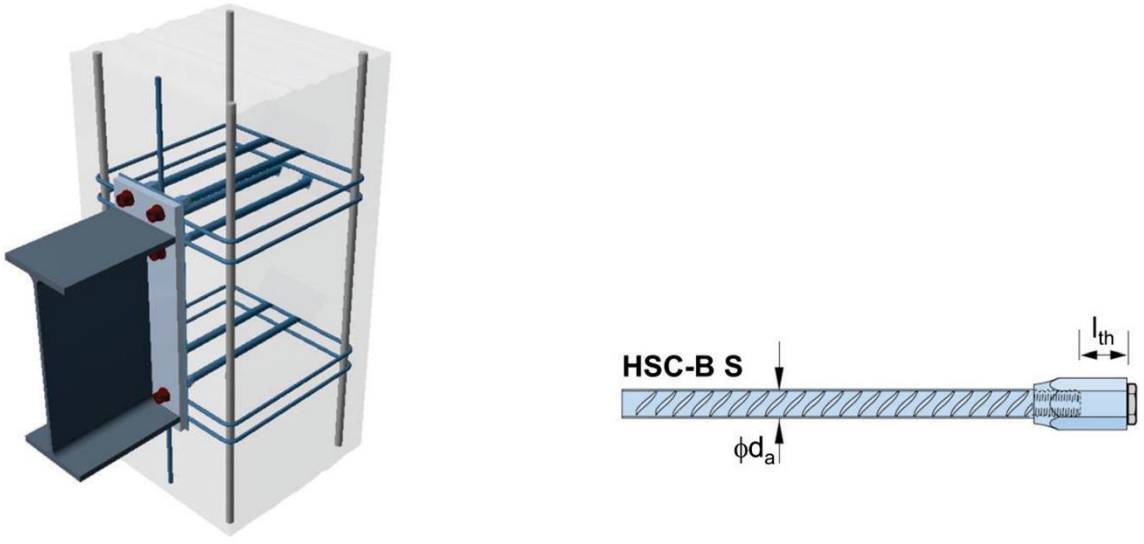

Fig. A6: Halfen Stud Connector type HSC-B S

Structural steelwork socket for mechanical connection with fastener, socket bars made from reinforcing steel for anchorage the connected loads in reinforced concrete structures

Halfen Stud Connector	Annex A4
Product description Product, installed conditions with structural steelwork socket bars “Halfen Stud Connector HSC-B“	

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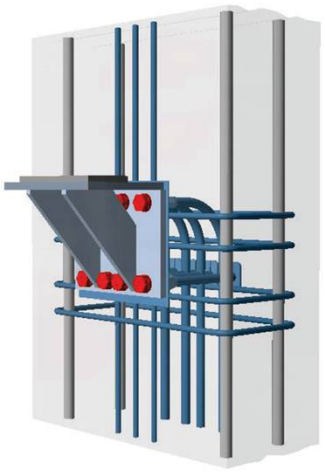
Bolted end-plate connection with
Halfen Stud Connector type HSC-B SB and HSC-B SH



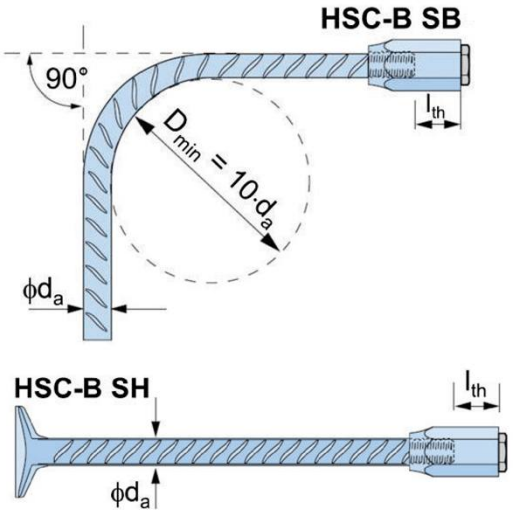


Fig. A7: Halfen Stud Connector type HSC-B SB and HSC-B SH

Structural steelwork socket for mechanical connection with fastener, socket bars with bend or anchor head made from reinforcing steel for anchorage the connected loads in reinforced concrete structures

Double-sided bolted end-plate connection with
Halfen Stud Connector type HSC-B SD

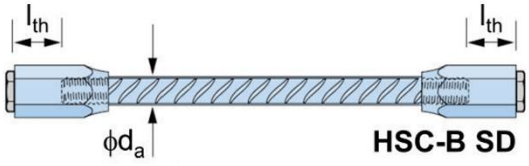


Fig. A8: Halfen Stud Connector type HSC-B SD

Structural steelwork socket for mechanical connection with fastener, double-sided socket bars made from reinforcing steel for anchorage or transmission the connected loads in reinforced concrete structures

Halfen Stud Connector	
Product description Product, installed conditions with structural steelwork socket bars “Halfen Stud Connector HSC-B“	Annex A5

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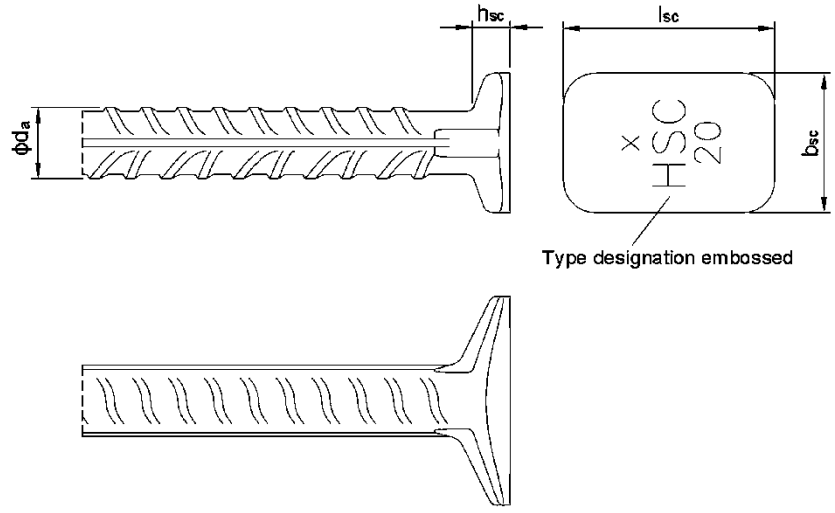
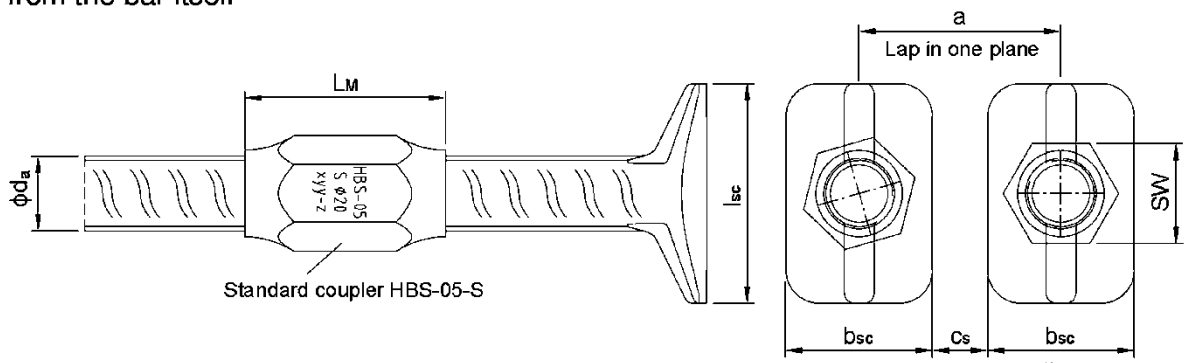
A.3 Dimensions

Types of headed rebar



a) Headed rebar from reinforcing steel, the rectangular anchor head is made by integrally hot-forging from the bar itself



b) Alternative type of headed rebar with mechanical splice of reinforcing steel bars[1)]

Fig. A9: Types of the headed rebars

Table A1: Dimensions of the headed rebar, dimensions and spacings for the mechanical splice

HSC			12	14	16	20	25
Nominal bar diameter	ϕd_a =	[mm]	12	14	16	20	25
Length of anchor head	l_{sc} =	[mm]	35	42	53	66	83
Width of anchor head	b_{sc} =	[mm]	30	34	35	44	55
Heigth of anchor head	h_{sc} =	[mm]	8	9	10	12	14
Load-bearing area of anchor head	A_h =	[mm²]	906	1232	1599	2504	3940
Coupler length[1)]	l_M =	[mm]	36	42	48	60	75
Wrench size[1)]	SW =	[mm]	19	22	24	30	36
Clearance between headed rebars[2)]	$c_s \geq$	[mm]	12	15	20	20	25
Spacing[2)]	a ≥	[mm]	42	49	55	64	80

[1)] Construction with standard coupler HBS-05-S in line with the Halfen threaded coupler system according to ETA-21/0800

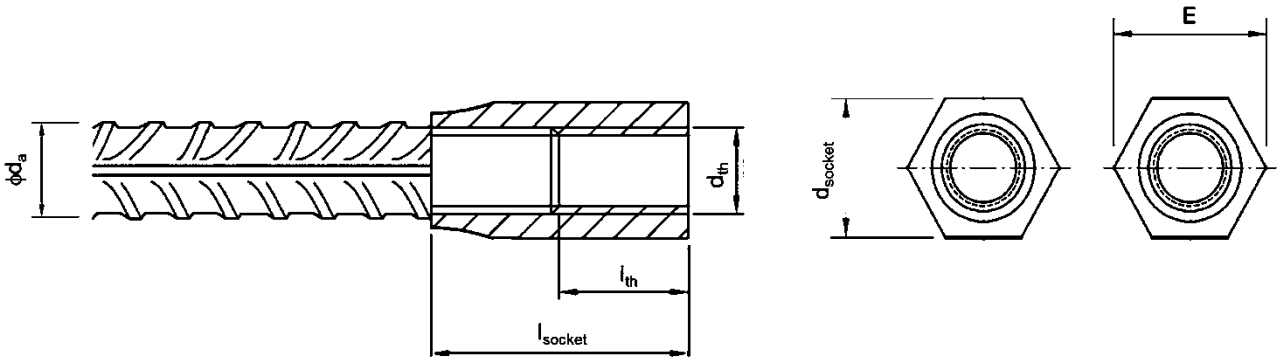
[2)] Spacings only required for installation of headed rebars with mechanical splice of reinforcing steel bars[1)]

Halfen Stud Connector

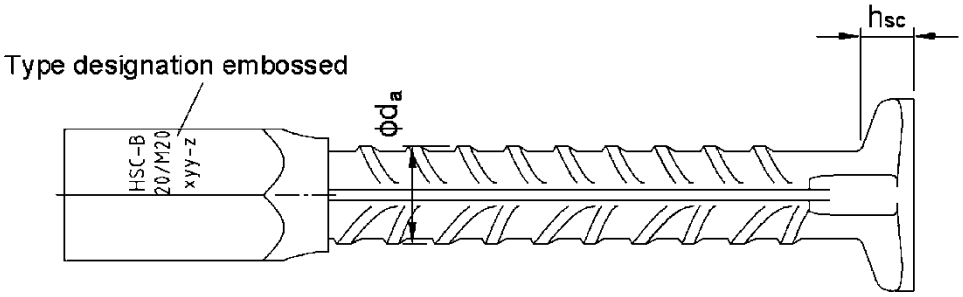
Product description
Dimensions, type of the headed rebar "Halfen Stud Connector HSC"

Annex A6

Types of structural steelwork socket bar



a) Reinforcing steel bar with a structural steelwork socket[1)]



b) Alternative type of structural steelwork socket bar[1)] with rectangular anchor head according to Annex A6, Table A1

Fig. A10: Types of structural steelwork socket bars

Table A2: Dimensions of structural steelwork socket

HSC-B			12	14	16	20	25
Nominal bar diameter	ϕd_a =	[mm]	12	14	16	20	25
Thread size[2)]	d_{th} =	[mm]	M12	M14	M16	M20	M27
Maximum screw-in length	l_{th} ≥	[mm]	16,5	19,5	22,5	28,5	36
Socket length	l_{socket} ≥	[mm]	36	42	48	60	75
Wrench size	d_{socket} =	[mm]	19	22	24	30	41
Width across corners	E =	[mm]	21,9	25,4	27,7	34,6	47,3

[1)] Manufacture of the thread and the structural steelwork socket in line with Halfen HBS-05 threaded coupler system according to ETA-21/0800

[2)] Internal thread of the structural steelwork socket, tolerance class 6H, for fixing with the fasteners according to Annex A10, Table A8

Halfen Stud Connector

Product description
Dimensions, type of the structural steelwork socket bar "Halfen Stud Connector HSC-B"

Annex A7

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A.4 Material

Table A3: Material of headed rebar „Halfen Stud Connector HSC“

Type	Annex	Nominal diameter ϕd_a				
		12	14	16	20	25
HSC-H	A6	B,R	B,R	B	B	B
HSC-HD	A6	B,R	B,R	B	B	B
HSC-S	A6	B,R	B,R	B	B	B
HSC-SD	A6	B,R	B,R	B	B	B
HSC-A	A6	B,R	B,R	B	B	B

B: B500B[1)], class A1 according to EN 13501-1
R: B500 NR with corrosion resistance class CRC III according to EN 1993-1-4, class A1 according to EN 13501-1
[1)] Welding joints if it is done at the manufacturing plant: butt joints in accordance with EN ISO 17660-1, welding process 24 – flash butt welding

Table A4: Material of structural steelwork socket bar „Halfen Stud Connector HSC-B“

Type	Annex	Nominal diameter ϕd_a				
		12	14	16	20	25
HSC-B SH	A7	B,R	B,R	B	B	B
HSC-B S	A7	B,R	B,R	B	B	B
HSC-B SB	A7	B,R	B,R	B	B	B
HSC-B SD	A7	B,R	B,R	B	B	B

B: B500B[1)], class A1 according to EN 13501-1
R: B500 NR with corrosion resistance class CRC III according to EN 1993-1-4, class A1 according to EN 13501-1
[1)] Welding joints if it is done at the manufacturing plant: butt joints in accordance with EN ISO 17660-1, welding process 24 – flash butt welding

Table A5: Material of standard coupler HBS-05-S[1)] for headed rebar „Halfen Stud Connector HSC“

Type	Annex	Nominal diameter ϕd_a				
		12	14	16	20	25
HSC-S	A6	A	A	A	A	A
HSC-SD	A6	A	A	A	A	A
HSC-A	A6	A	A	A	A	A

A: 1.0715 according to EN 10277, class A1 according to EN 13501-1, electroplated zinc coating
[1)] Halfen HBS-05 threaded coupler system in accordance with ETA-21/0800

Table A6: Socket material of structural steelwork socket bar „Halfen Stud Connector HSC-B“

Type	Annex	Nominal diameter ϕd_a / Thread d_{th}				
		12 / M12	14 / M14	16 / M16	20 / M20	25 / M27
HSC-B SH	A7	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N
HSC-B S	A7	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N
HSC-B SB	A7	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N
HSC-B SD	A7	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N	A,L,M,N

A: 1.0715 according to EN 10277 with $R_{p0,2} \geq 440$ N/mm², class A1 acc. to EN 13501-1, electroplated zinc coating
L: 1.0715 according to EN 10277 with $R_{p0,2} \geq 440$ N/mm², class A1 acc. to EN 13501-1, hot-dipped galvanized
M: 1.4571 according to EN 10088-3 with $R_{p0,2} \geq 440$ N/mm², class A1 according to EN 13501-1
N: 1.4404 according to EN 10088-3 with $R_{p0,2} \geq 440$ N/mm², class A1 according to EN 13501-1

Halfen Stud Connector	
Product description Material	Annex A8

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A.5 Material version

Structural steelwork socket bar

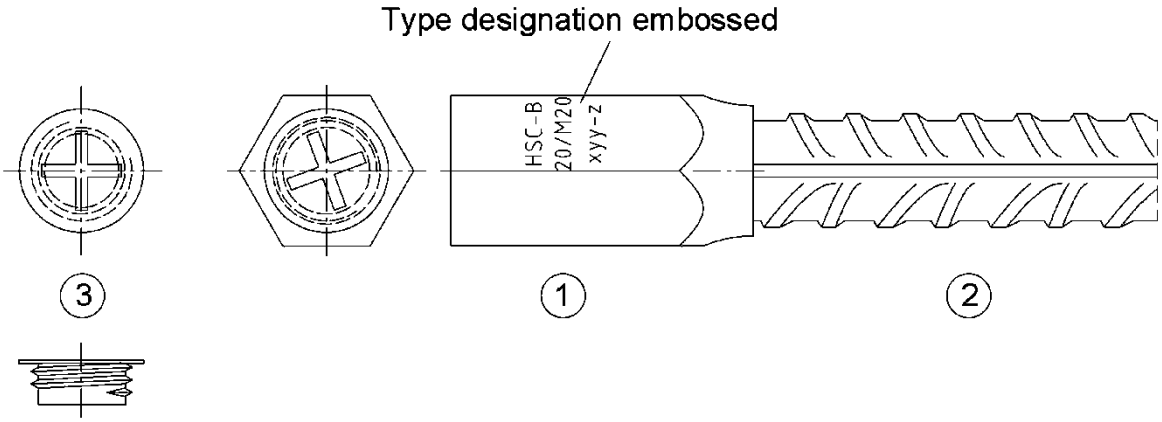


Fig. A11: Components of the structural steelwork socket bar "Halfen Stud Connector HSC-B"

Table A7: Material version of the structural steelwork socket bar

Item	Component	Material version			
		Material 1: Socket electroplated zinc coating (GV)	Material 2: Socket hot-dipped galvanized (FV)	Material 3: Socket in stainless steel (A4)	
1	Structural steelwork socket	Steel[3]: 1.0715 acc. to EN 10277, electroplated zinc coating[1]	Steel[3]: 1.0715 acc. to EN 10277, hot-dipped galvanized[2]	Stainless steel[3]: CRC III according to EN 1993-1-4: 1.4571 / 1.4404 in accordance with EN 10088-3	
2	Ribbed reinforcing steel or headed ribbed reinforcing steel bar with rectangular anchor head according to Annex A7	Weldable ribbed reinforcing steel bars[3]: B500B in accordance with EN 1992-1-1, Annex C		Weldable ribbed reinforcing steel bars[3]: B500B in accordance with EN 1992-1-1, Annex C	Weldable ribbed reinforcing stainless steel bars[3] B500 NR: CRC III acc. to EN 1993-1-4: 1.4571 / 1.4362
3	Thread sealing plug	LDPE			

[1] Thickness of coating ≥ 5µm in accordance with EN ISO 4042
[2] Thickness of coating ≥ 35-45µm in accordance with EN ISO 1461 or EN ISO 10684
[3] Class A1 according to EN 13501-1

Halfen Stud Connector	
Product description Material version of structural steelwork socket bar "Halfen Stud Connector HSC-B"	Annex A9

Table A8: Material version of the fastener and supplementary reinforcement
(Washer, screw or rather threaded bolt with nut, supplementary reinforcement, mounting template not included with the socket bar kit)

Item	Component	Material version		
		Material 1: Socket electroplated zinc coating (GV)	Material 2: Socket hot-dipped galvanized (FV)	Material 3: Socket in stainless steel (A4)
1	Socket bar[1)]	HSC-B socket bar according to Table A7, material 1	HSC-B socket bar according to Table A7, material 2	HSC-B socket bar according to Table A7, material 3
2	Washer in accordance with EN ISO 7089 or EN ISO 7093-1	Steel[5)] acc. to EN 10025-2, zinc coated	Steel[5)] acc. to EN 10025-2, hot-dipped galvanized	Stainless steel[5)]: CRC III acc. to EN 1993-1-4: 1.4401 / 1.4404 / 1.4435 / 1.4571 / 1.4429 / 1.4432 / 1.4162 / 1.4662 / 1.4362 / 1.4062 / 1.4578 in accordance with EN 10088-2
3	Screw or threaded bolt	Steel[5)] according to EN ISO 898-1, zinc coated[2)], bolt class: 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 10.9 or 12.9	Steel[5)] according to EN ISO 898-1, hot-dipped galvanized[3)] tZn, bolt class with additional marking „U“: 4.6U, 4.8U, 5.6U, 5.8U, 6.8U, 8.8U, 10.9U or 12.9U	Stainless steel[5)]: CRC III acc. to EN 1993-1-4: 1.4401 / 1.4404 / 1.4578 / 1.4571 / 1.4435 / 1.4362 / 1.4062 / 1.4162 / 1.4662 in accordance with EN ISO 3506-1, bolt class 50, 70, 80 or 100
4	Nut[4)]	Steel[5)] according to EN ISO 898-1, zinc coated[2)], bolt class: 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 10.9 or 12.9	Steel[5)] according to EN ISO 898-1, hot-dipped galvanized[3)] tZn, bolt class: 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 10.9 or 12.9	Stainless steel[5)]: CRC III acc. to EN 1993-1-4: 1.4401 / 1.4404 / 1.4578 / 1.4571 / 1.4435 / 1.4362 / 1.4062 / 1.4162 / 1.4662 in accordance with EN ISO 3506-2, bolt class 50, 70, 80 or 100
5	Supplementary reinforcement	Reinforcing steel[5)] B500A / B500B	Reinforcing steel[5)] B500A / B500B	Stainless reinforcing steel[5)] accordingly respective CRC or rather B500A or B500B taken into account the respective concrete cover c_{min} according to EN 1992-1-1
6	Mounting template, if relevant	Steel[5)] acc. to EN 10025-2, zinc coated	Steel[5)] acc. to EN 10025-2, hot-dipped galvanized	Stainless steel[5)] according to EN 10088-2 and respective CRC

[1)] The inner area of the structural steelwork socket is to be protected against ingress of dirt and humidity until application (mounting of fixture), e.g. by using the thread sealing plug according to Annex A9, Table A7, line 3 or the screw according to Annex 10, Table A8, line 3
[2)] Thickness of coating ≥ 5µm in accordance with EN ISO 4042
[3)] Thickness of coating ≥ 40µm in accordance with EN ISO 10684
[4)] Use with threaded bolt
[5)] Class A1 according to EN 13501-1

Halfen Stud Connector

Product description
Material version of fastener components and reinforcement

Annex A10

B.1 Specifications of intended use

Anchorages subject to:

- Static, quasi-static and fatigue loads
- Fire exposure: only for concrete C20/25 to C70/85

Base material:

- Reinforced compacted normal weight concrete of strength classes C20/25 to C70/85 according to EN 206

Use conditions:

- Headed rebars at end supports of beams, slabs or walls with dimension and supplementary reinforcement in accordance with Annex B7
- Headed rebars in corbel-column-joints with dimension and supplementary reinforcement in accordance with Annex B8 or Annex B9
- Headed rebars in exterior beam-column-joints with dimension and supplementary reinforcement in accordance with Annex B10
- Headed rebars in corbel-column-joints cast at different times that transmit shear stress at the interface between concrete cast at different times with dimension in accordance with Annex B11
- Structural steelwork socket anchors in reinforced concrete structures for bolted end-plate connections with dimension, supplementary reinforcement, edge distances and axial spacings in accordance with Annexes B12 to B14

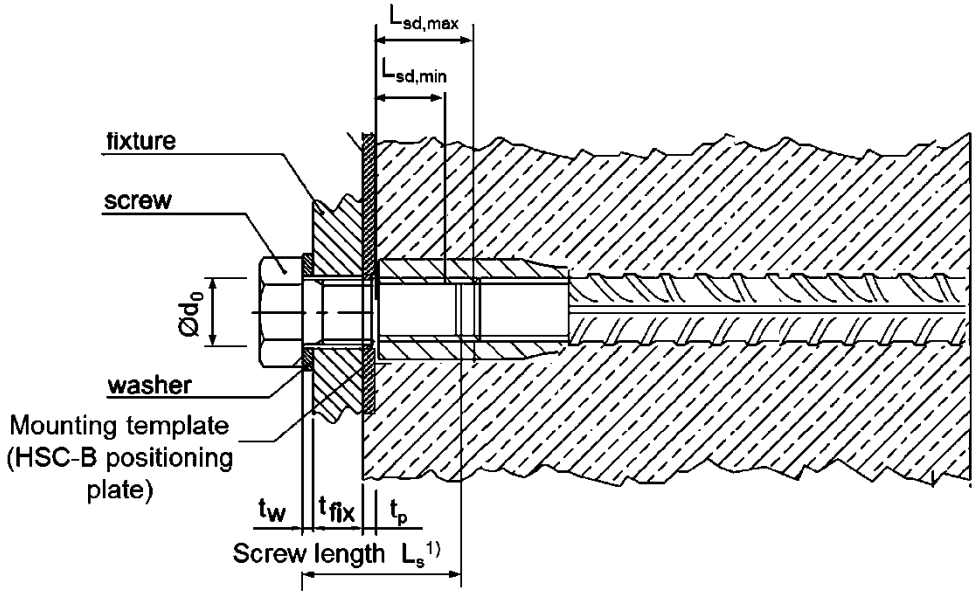
Design:

- Design and detailing the anchorage zone of headed rebars in accordance with EN 1992-1-1 and EOTA TR 081
- Design and detailing the anchorage zone of structural steelwork socket bars and bolted end-plate connection in accordance with:
  - EN 1993-1-1 and EN 1993-1-8 (Resistance of the end-plate)
  - EN 1993-1-4 (Resistance of stainless steel component parts)
  - EN 1993-1-8 (Resistance of the bolts)
  - EN 1992-1-1 and EOTA TR 081 (Resistance of combined shear and tension for the bolt or structural steelwork socket, tensile or anchorage resistance of the socket bars and resistance of concrete failure)
- Design of fatigue loading according to EN 1992-1-1, Clause 6.8.4 or EN 1993-1-9
- Requirements for the bolted end-plate:
  - Hole diameter for the fastener in accordance with Annex B2, Table B1
  - Extensive smooth contact to the structural steelwork connection area in the supporting concrete element, if applicable a structural splice with beneficial impact due to friction caused by bending and/or compression force of the fixture, coefficient of friction for the joint in accordance with Annex B13, Table B8
- Requirements for the fastener:
  - Material in accordance with Annex A10, Table A8
  - Screw-in length in accordance with Annex B2, Table B1
- Requirements for the anchor- or structural steelwork socket bars:
  - Minimum concrete cover for the anchor head or the structural steelwork socket in accordance with EN 1992-1-1

Halfen Stud Connector	Annex B1
Intended use Specifications	

B.2 Installation requirements

- Installation and mounting of fixture by appropriate qualified personnel under the supervision of the person responsible for technical matters on site shall be carried out in compliance with the installation instruction and installation regulations given in Annexes B3 to B14.
- Threads shall be checked for proper condition before use. The threads shall be clean and free from rust. Suitable measures, such as temporary use of sealing plugs or caps, shall be taken to protect the threads against oil, humidity or ingress of dirt until application (installation of a threaded continuation bar or mounting of the fixture).
- Headed or structural steelwork socket bars are to be wire-tied to the element reinforcement. When placing the concrete, make sure that the bars are secured in their position. Large impact forces on the bars are to be avoided. Compact the concrete carefully in the area of the anchor heads and sockets, avoid direct contact between compacting device and the bars.
- The fixture is bolted to the mounting template, the face side of the structural steelwork socket bars or to the concrete (socket anchors installed recessed to the connection level). When tightening the bolts on recessed embedded structural steelwork socket bars without suitable shimming of the cavities to the connection level of the end-plate, the maximum pre-tensioning forces according to Annex B2, Table B1 shall be observed.



1) $t_w + t_{fix} + t_p + L_{sd,min} \le L_s \le t_w + t_{fix} + t_p + L_{sd,max}$

Fig. B1: Position of the fixture

Table B1: Installation parameters of structural steelwork socket bar "Halfen Stud Connector HSC-B"

HSC-B			12	14	16	20	25
Thread size	d_{th} =	[mm]	M12	M14	M16	M20	M27
Minimum screw-in length	$L_{sd,min}$ =	[mm]	12	14	16	20	27
Maximum screw-in length	$L_{sd,max}$ ≥	[mm]	16,5	19,5	22,5	28,5	36
Clearance hole in the fixture	$Ød_0$ ≤	[mm]	13	15	18	22	30
Max. pre-tension force[1)]	F_{pr} ≤	[kN]	31,1	42,7	58,6	91,6	173,3

1) Only for structural steelwork socket bars embedded sunk to the connection level without a suitable shimming of the cavities.

Halfen Stud Connector

Intended use
Installation requirements, position of the fixture, installation parameters

Annex B2

B.3 Installation instruction

Installation of headed rebars "Halfen Stud Connector HSC"

Select the headed rebars HSC-H, HSC-HD in accordance with the specifications of the planning documents. Wire-tied the headed rebars to the element reinforcement in the formwork, taking into account the concrete cover and alignment of the anchor heads.

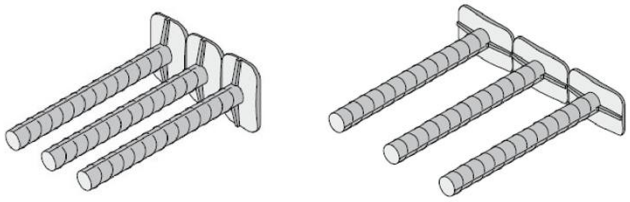


Fig. B2: Possible alignment of anchor heads

Installation of headed rebars with mechanical splice of reinforcing steel bars

Select the headed coupler bars (HSC-S, HSC-SD) and/or headed continuation rebars with threaded sleeve (HSC-A) according to the specifications of the planning documents. The coupler bars shall be fixed to the formwork exactly in the axis direction of the continuation bar. Any deviations may compromise the necessary anchorage length of the continuation bar and concrete cover of the anchor head in the second concreting section. To ensure installation of headed continuation bars, the minimum spacing according to Annex A6, Table A1 shall be taken into account. Subsequent bending in the thread area is not permitted. Add the element reinforcement in the formwork and fix it in an appropriate manner.

Fixing coupler bars on wooden formwork

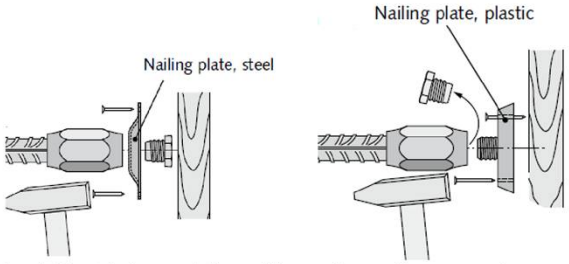


Fig. B3: Fixing with nailing plate (formwork accessory)

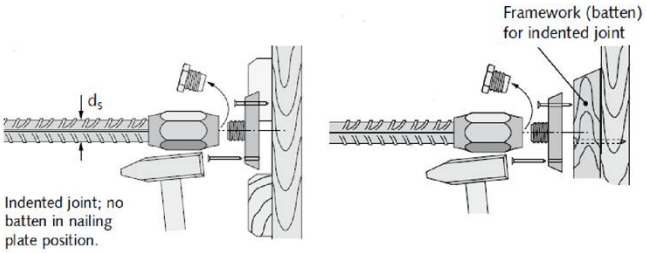


Fig. B4: Fixing with nailing plate (formwork accessory) and creation of a recess for shear loads

Fixing coupler bars on steel formwork

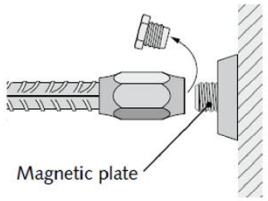


Fig. B5: Fixing with magnetic or adhesive plate (formwork accessory)

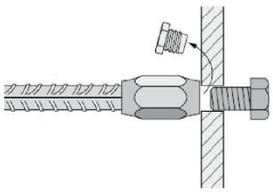


Fig. B6: Fixing with hexagonal screw

Halfen Stud Connector	
Intended use Installation instruction – part 1	Annex B3

Deutsches Institut für Bautechnik DIBt

Installation of headed continuation bars (2nd concreting phase)

Once the concrete has reached sufficient strength, the thread protection is removed, then the continuation bar should be positioned at the coupler location and rotated to fit into the coupler thread. The connection should then be tightened by using a hand wrench until the conical area of the thread end. Final screwing in and tightening requires an appropriate tool and is finished when the last thread turn is no longer visible and the anchor head is aligned as planned. Subsequent bending in the thread area is not permitted. Add the element reinforcement in the formwork and fix it in an appropriate manner.

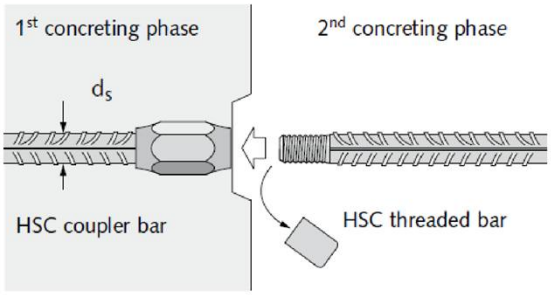


Fig. B7: Installation principle for mechanical splice of reinforcing steel bars

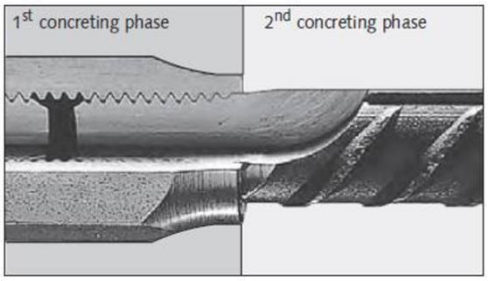


Fig. B8: Fully screwed-in connection thread

Installation of structural steelwork socket bars "Halfen Stud Connector HSC-B"

Select the structural steelwork socket bars (HSC-B S, HSC-B SH, HSC-B SD or HSC-B SB) according to the specifications of the planning documents. Fix the socket bars to the formwork in the specified axial alignment using the mounting template, screws or formwork accessories. Subsequent bending in the thread area is not permitted. Add the element reinforcement in the formwork and fix it in an appropriate manner.

The connection level in the concrete element is formed from the mounting template and the structural steelwork socket bars. The connection level can be arranged either flush with concrete or recessed. For the connection level flush with concrete, the HSC-B socket bars are fixed directly to the formwork using the mounting template and screws. Holes shall be drilled in the formwork for this purpose. For the recessed connection level, the HSC-B socket bars are first fastened to the mounting template with flat-head bolts (assembling accessory), then the mounting template is placed with the screw heads on the formwork and fastened using conventional methods. The cavity between the mounting template and the formwork shall be protected from concrete ingress with a sealant.

Concrete-flush connection level

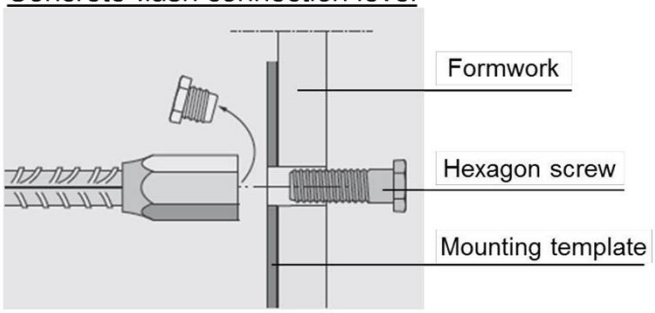


Fig. B9: Installation principle for concrete-flush connection level: mounting template is attached to the formwork

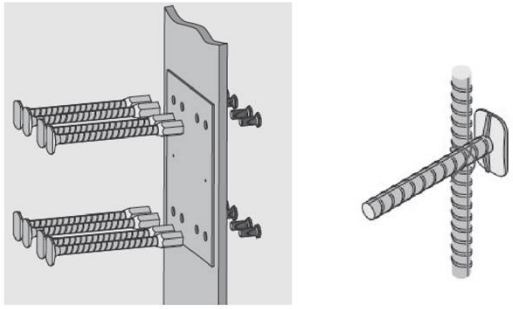


Fig. B10: Fix HSC-B socket bars with mounting template and hexagonal screws to the formwork, wire-tied the socket bars to the element reinforcement

Halfen Stud Connector	
Intended use Installation instruction – part 2	Annex B4

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Recessed connection level

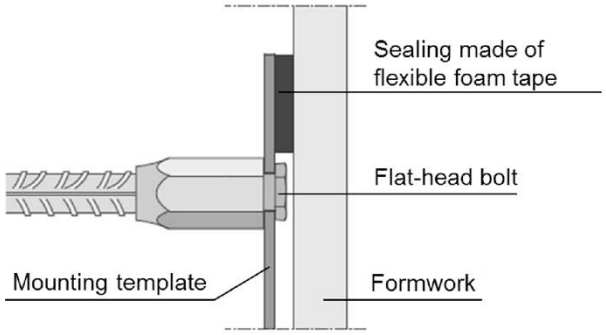


Fig. B11: Installation principle for recessed connection level: mounting template inset from face of concrete, cavity to the formwork

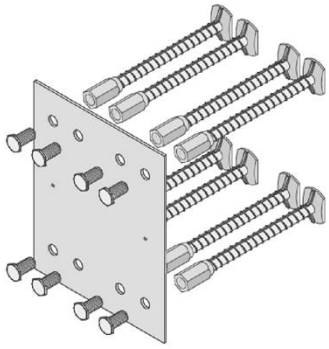


Fig. B12: Screw the HSC-B socket bars to the mounting template with flat-head bolts (assembling accessory)

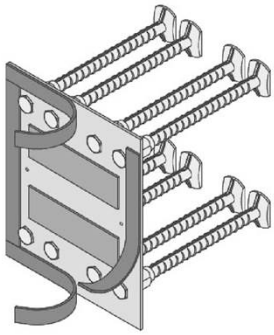


Fig. B13: Apply circumferential sealing made of flexible foam tape (assembling accessory)

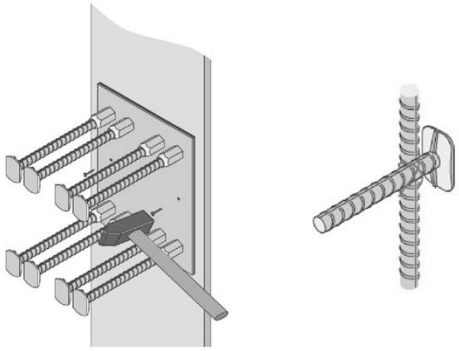


Fig. B14: Fix the mounting template to the formwork, wire-tied the HSC-B socket bars to the element reinforcement

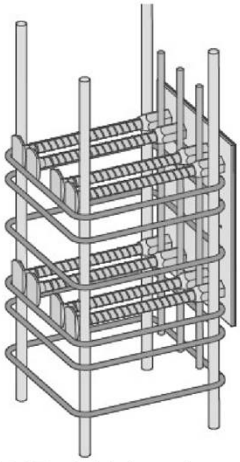


Fig. B15: Add the element reinforcement in the formwork

Bending on site

Bending of socket or continuation bars is only permissible if the distance between the end of the socket or the thread and the beginning of the bend is minimum $5 \cdot d_a$.

Welding on site

Welding in the bending area of the bars or on the sockets is not permitted. Welding outside bending areas is carried out according to EN 1992-1-1 under sole responsibility of the welding-contractor.

Halfen Stud Connector	
Intended use Installation instruction – part 3	Annex B5

Mounting of fixture to the structural steelwork socket

When the concrete has reached sufficient strength, remove the formwork and assembling accessories, check the internal thread for dirt, clean if necessary. Select the washer, screw or threaded bolt with nut according to the specifications of the planning documents and check the required screw length with the values on the minimum and maximum screw-in depth according to Annex B2, Table B1. The mounting template also serves as a part of connection level and can remain in the concrete element. For installation, clean the connection surfaces from dirt, sealant or oil. Tightening the fixture at least hand-tight according to the specifications of the planning documents.
Additionally take care to the Engineer's details for the fixture. For two-sided configurations, the intended installation sequence or the temporary reduced load-bearing resistances in the installation state shall be taken into account.

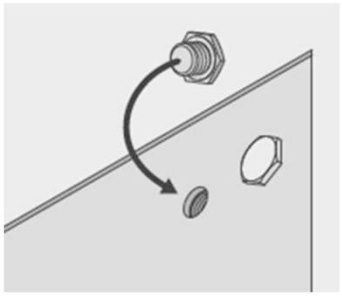


Fig. B16: Remove assembling accessories, check if the inside of the threaded socket is free from dirt, otherwise clean it

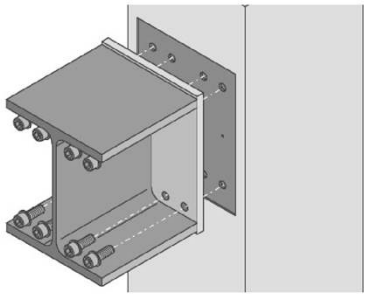
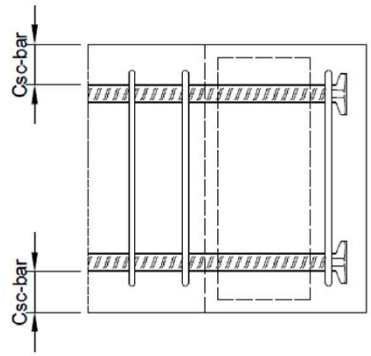
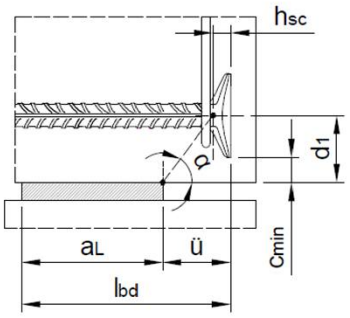


Fig. B17: Mounting of fixture: Tightening the fasteners starting from the area of highest stiffness to the area of lowest stiffness of the connection

B.4 Installation regulations

Headed rebars type “HSC-H” at end supports of beams, solid slabs and walls





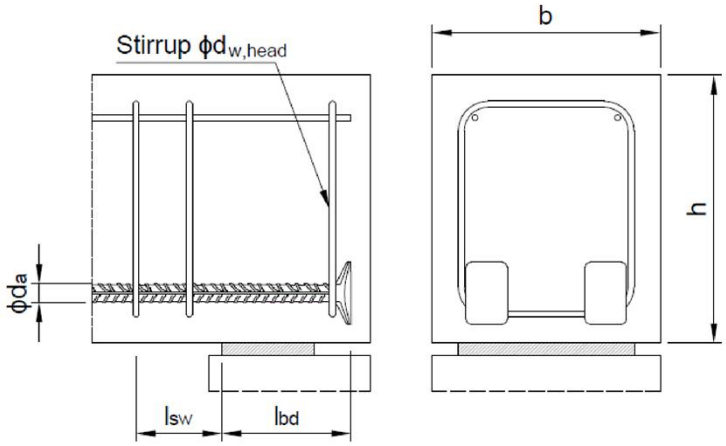


Fig. B18: Dimensioning and detailing of end supports

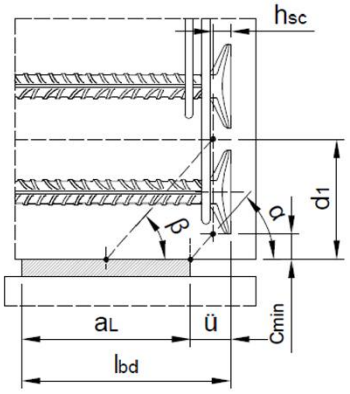


Fig. B19: Anchorage length at end supports for single or multiple layer of reinforcement

Table B2: Dimension of end supports

Type	ϕd_a	$b^{1)}$	$h^{1)}$	$\phi d_{w,head}{}^{2)}$	$c_{sc\text{-}bar}$	α	ß	Concrete strength class
	[mm]	[mm]	[mm]	[mm]	[mm]	[°]	[°]	[-]
HSC-H 12	12	≥ 200	≥ 200	≥ 6	≥ 30	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-H 14	14	≥ 200	≥ 200	≥ 6	≥ 35	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-H 16	16	≥ 200	≥ 200	≥ 6	≥ 40	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-H 20	20	≥ 300	≥ 300	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C20/25 – C25/30
		≥ 240	≥ 200	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C30/37 – C35/45
		≥ 200	≥ 200	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C40/50 – C70/85
HSC-H 25	25	≥ 300	≥ 400	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C20/25
		≥ 300	≥ 350	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C25/30 – C30/37
		≥ 300	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C35/45 – C70/85

[1] The minimum dimensions b and h may be reduced if the anchorage of the tension force at the end support can be verified in accordance with EOTA TR 081

[2] For solid slabs, at least 20% of the principal reinforcement should be provided as transverse reinforcement within the support or at near of the anchor heads

Halfen Stud Connector

Intended use
Installation regulations for end supports

Annex B7

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Headed rebars type "HSC-HD" in corbel-column-joints

- Alternative double-sided corbel possible
- Alternative with construction joint to the column and mechanical splice of the headed rebars according to Annex B11 possible

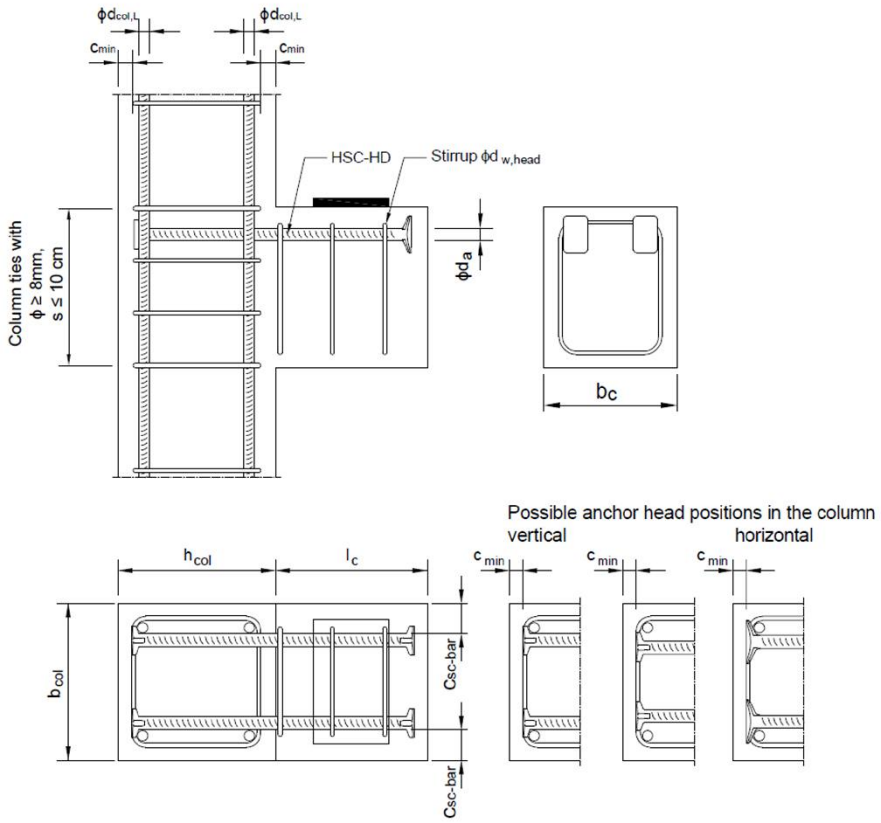


Fig. B20: Dimensioning and detailing of corbel-column-joints

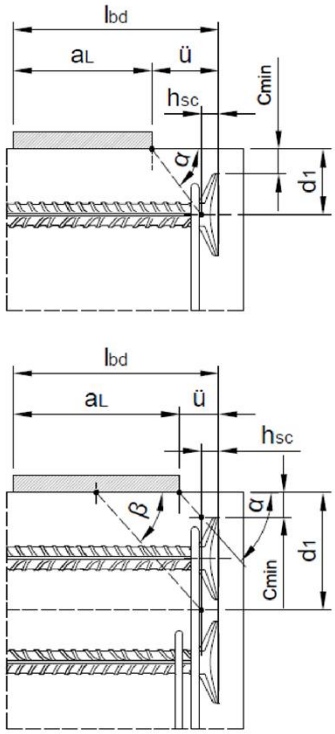


Fig. B21: Anchorage length in the corbel for single or multiple layer of reinforcement

Table B3: Dimension of corbel-column-joints

Type	ϕd_a	h_{col}	b_{col}	$\phi d_{col,L}$	l_c [1)]	b_c [1)]	$\phi d_{w,head}$	$c_{sc\text{-}bar}$	α	β	Concrete strength class
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]	[°]	[-]
HSC-HD 12	12	≥ 240	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 30	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-HD 14	14	≥ 240	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 35	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-HD 16	16	≥ 240	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 40	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-HD 20	20	≥ 300	≥ 300	≥ 16	≥ 300	≥ 300	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C20/25 – C25/30
		≥ 300	≥ 300	≥ 16	≥ 200	≥ 240	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C30/37 – C35/45
		≥ 240	≥ 240	≥ 16	≥ 200	≥ 200	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C40/50 – C70/85
HSC-HD 25	25	≥ 400	≥ 300	≥ 20	≥ 400	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C20/25
		≥ 350	≥ 300	≥ 20	≥ 350	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C25/30 – C30/37
		≥ 300	≥ 300	≥ 20	≥ 300	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C35/45 – C70/85

1) The minimum dimensions l_c and b_c may be reduced if the anchorage of the tension force in the corbel can be verified in accordance with EOTA TR 081

Halfen Stud Connector

Intended use
Installation regulations for corbel-column-joints

Annex B8

Headed rebars type “HSC-A” for subsequently connected corbels

- Design of interfaces between concrete cast at different times according to Annex B11
- Spacing of headed rebars with mechanical splice according to Annex A6, Table A1
- Anchoring of the tensile force on the opposite column side by transfer to the element reinforcement with a corresponding lap in accordance with EN 1992-1-1
- Alternative double-sided corbel with double coupler rebar type “HSC-SD” possible

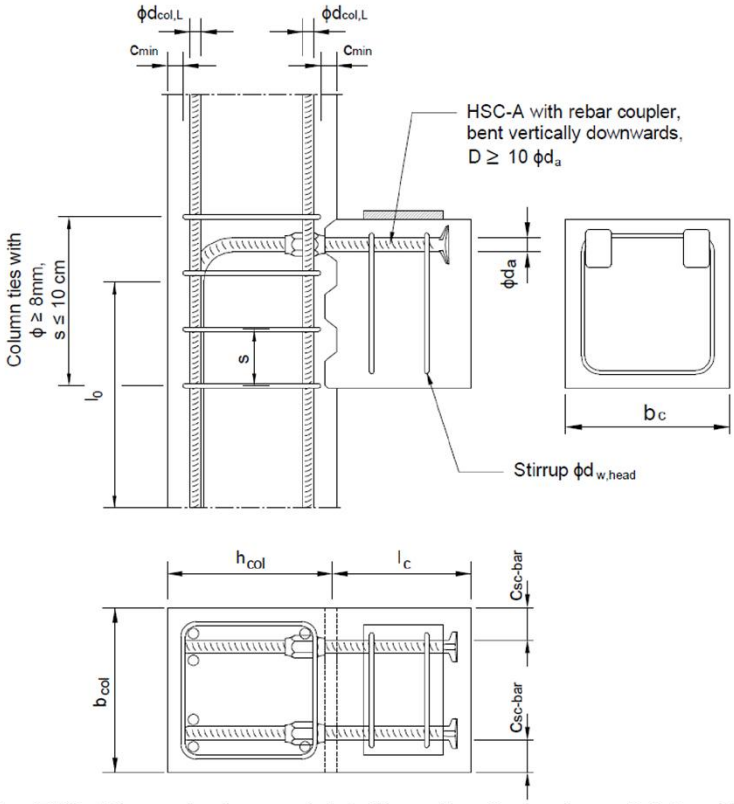


Fig. B22: Dimensioning and detailing of corbel-column-joints with casting segment

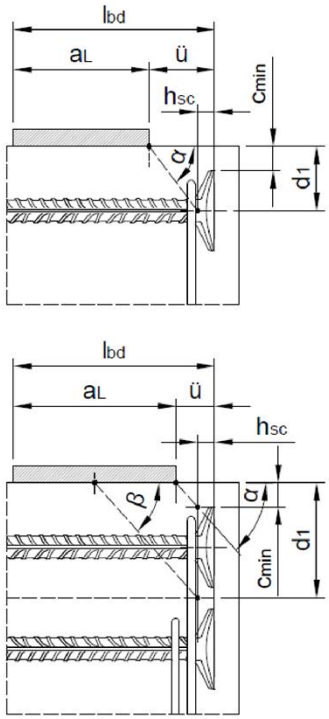


Fig. B23: Anchorage length in the corbel for single or multiple layer of reinforcement

Table B4: Dimension of corbel-column-joints with casting segment

Type	ϕda	bcol	ϕdcol,L	lc[1)]	bc[1)]	ϕdw,head	csc-bar	α	ß	Concrete strength class
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]	[°]	[-]
HSC-A 12	12	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 30	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-A 14	14	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 35	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-A 16	16	≥ 240	≥ 12	≥ 200	≥ 200	≥ 6	≥ 40	≤ 63,4	≤ 63,4	C20/25 – C70/85
HSC-A 20	20	≥ 300	≥ 16	≥ 300	≥ 300	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C20/25 – C25/30
		≥ 300	≥ 16	≥ 200	≥ 240	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C30/37 – C35/45
		≥ 240	≥ 16	≥ 200	≥ 200	≥ 8	≥ 50	≤ 63,4	≤ 63,4	C40/50 – C70/85
HSC-A 25	25	≥ 300	≥ 20	≥ 400	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C20/25
		≥ 300	≥ 20	≥ 350	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C25/30 – C30/37
		≥ 300	≥ 20	≥ 300	≥ 300	≥ 10	≥ 60	≤ 63,4	≤ 63,4	C35/45 – C70/85

[1)] The minimum dimensions l_c and b_c may be reduced if the anchorage of the tension force in the corbel can be verified in accordance with EOTA TR 081

Halfen Stud Connector

Intended use
Installation regulations for subsequently connected corbel-column-joints

Annex B9

Deutsches Institut für Bautechnik DIBt

Headed rebars type "HSC-H" in exterior beam-column-joints

- Alternative with construction joint to the column and mechanical splice of the headed rebars according to Annex B11 possible

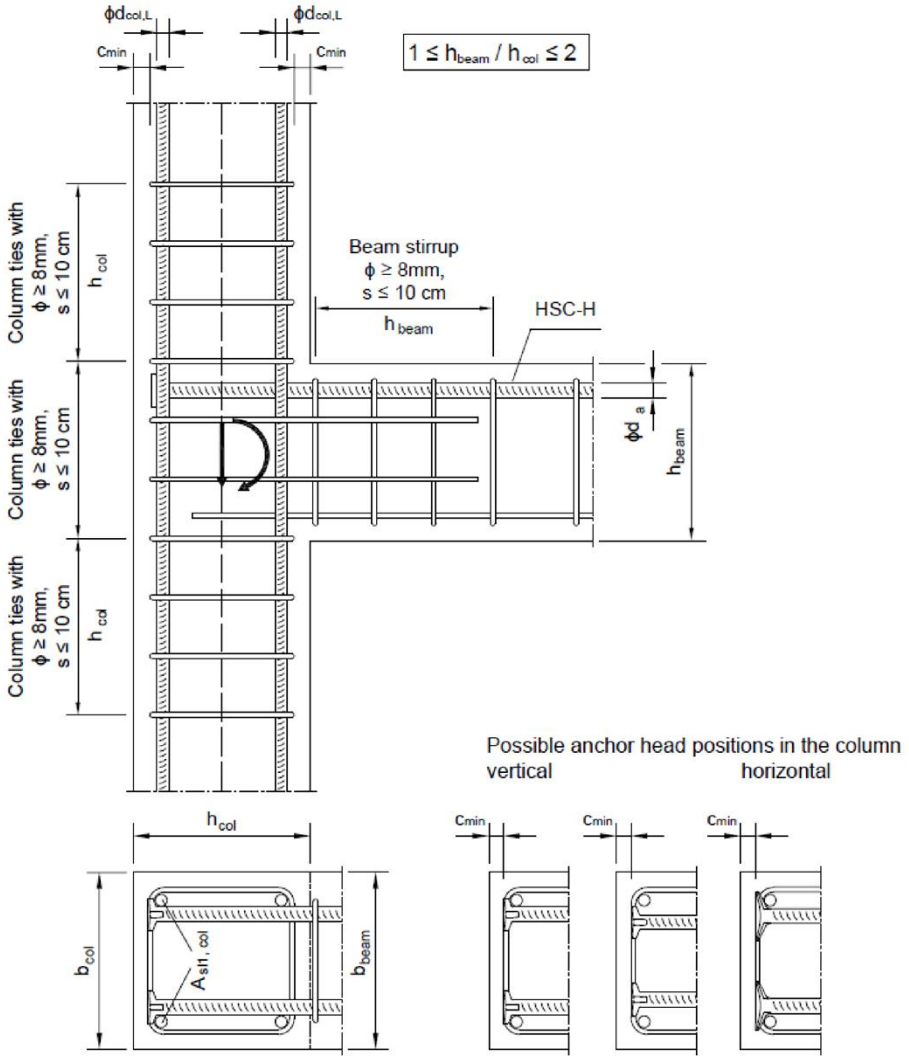


Fig. B24: Dimensioning and detailing of exterior beam-column-joints

Table B5: Dimension of exterior beam-column-joints

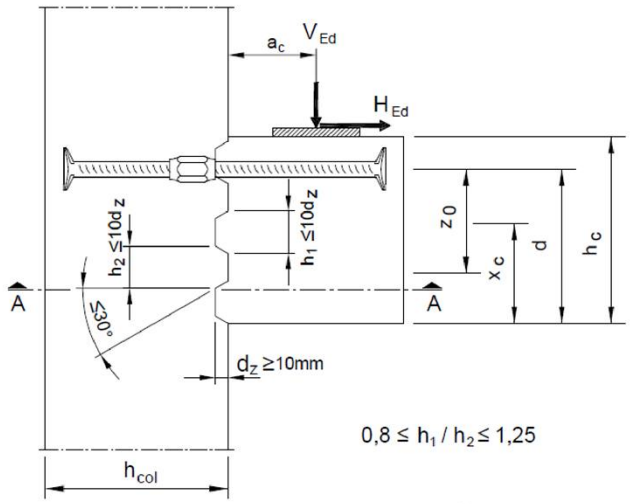
Type	ϕd_a	h_{col}	b_{col}	$\phi d_{col,L}$	h_{beam}	b_{beam}	Concrete strength class
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[-]
HSC-H 12	12	≥ 240	≥ 240	≥ 12	≥ 240	≥ 160	C20/25 – C70/85
HSC-H 14	14	≥ 240	≥ 240	≥ 12	≥ 240	≥ 160	C20/25 – C70/85
HSC-H 16	16	≥ 240	≥ 240	≥ 12	≥ 240	≥ 160	C20/25 – C70/85
HSC-H 20	20	≥ 300	≥ 300	≥ 16	≥ 300	≥ 160	C20/25 – C35/45
		≥ 240	≥ 240	≥ 16	≥ 240	≥ 160	C40/50 – C70/85
HSC-H 25	25	≥ 400	≥ 300	≥ 20	≥ 400	≥ 160	C20/25
		≥ 350	≥ 300	≥ 20	≥ 350	≥ 160	C25/30 – C30/37
		≥ 300	≥ 300	≥ 20	≥ 300	≥ 160	C35/45 – C70/85

Halfen Stud Connector

Intended use
Installation regulations for exterior beam-column-joints

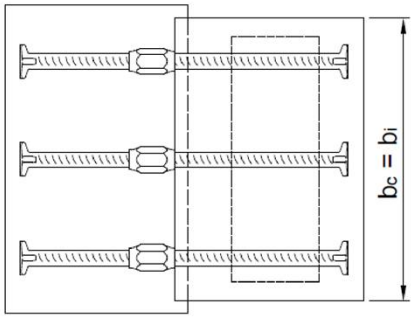
Annex B10

Construction joints to column with mechanical splice of headed rebars



$0{,}8 \leq h_1 / h_2 \leq 1{,}25$

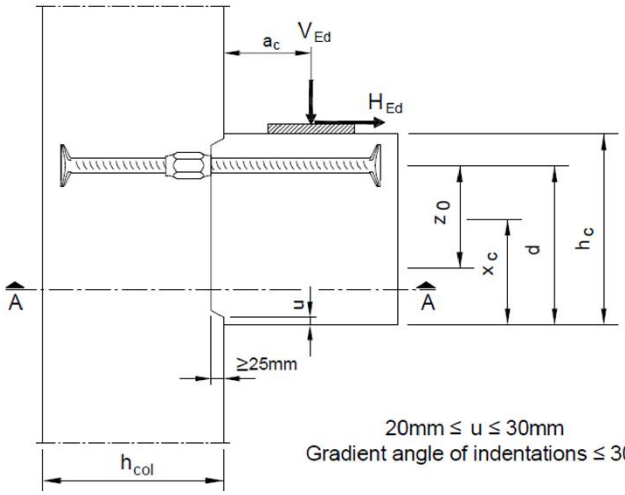
Section A-A



$x_i = h_c$
$h_i = h_c$
$x_c = 2 \cdot (d - z_0)$

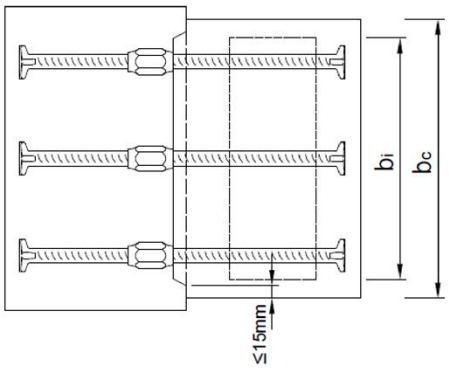
In the case of surface with multiple indentations the indent spacing shall not be less than the largest aggregate size in the concrete mix.

Fig. B25: Dimensioning and detailing of indented construction joints (Type A)



20mm ≤ u ≤ 30mm
Gradient angle of indentations ≤ 30°

Section A-A



$x_i = h_i$ if $H_{Ed} \leq 0$
$x_i = x_c - u \leq 500$ mm if $H_{Ed} > 0$
$h_i = h_c - u \leq 500$ mm
$x_c = 2 \cdot (d - z_0)$

Fig. B26: Dimensioning and detailing of single indented construction joints (Type B)

Table B6: Roughness factor, coefficient of friction and strength reduction factor according to surface category

Surface category / Type of construction joint[1)]		c	μ	ν_i
		[-]	[-]	[-]
A	Indented (surface with multiple indentations)	0,5	0,9	0,7
B	Single indented (surface with one single indentation)	0,4	0,7	0,5

[1)] Mechanical splice of headed rebars with standard coupler HBS-05-S in line with Halfen HBS-05 threaded coupler system in accordance with ETA-21/800

Halfen Stud Connector

Intended use
Installation regulations for construction joints to the column

Annex B11

Structural steelwork socket bars type “HSC-B SH” for bolted end-plate connections

- Coefficient of friction between end-plate and connection plane according to Annex B13, Table B8

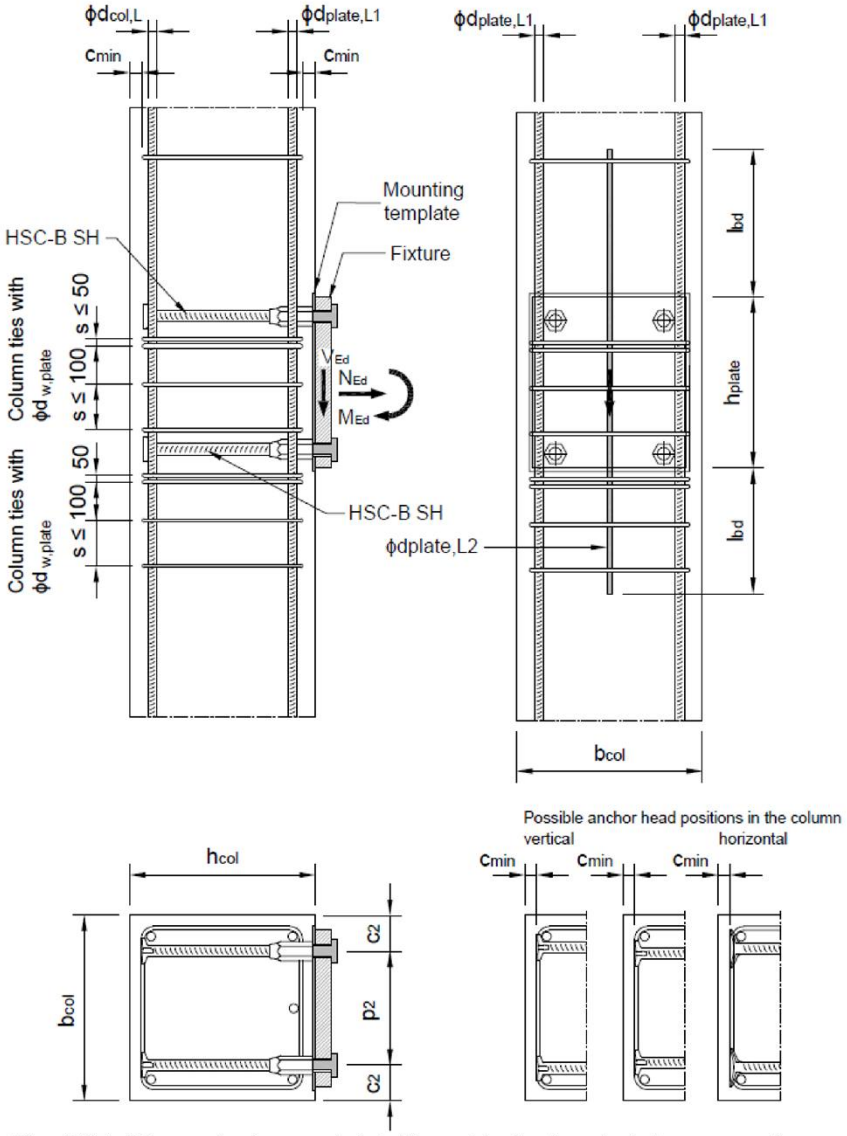


Fig. B27: Dimensioning and detailing of bolted end-plate connections

Table B7: Dimension of bolted end-plate connections at reinforced concrete structures (rebars with anchor head)

Type	ϕd_a	d_{th}	h_{col}	b_{col}	c_2	p_2	$\phi d_{col,L}$	$\phi d_{plate,L1}$	$\phi d_{plate,L2}$	$\phi d_{w,plate}$	Concrete strength class
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
HSC-B SH 12	12	M12	≥ 240	≥ 240	≥ 40	≥ 30	≥ 12	≥ 12	≥ 10	≥ 6	C20/25 – C70/85
HSC-B SH 14	14	M14	≥ 240	≥ 240	≥ 46	≥ 35	≥ 12	≥ 12	≥ 10	≥ 6	C20/25 – C70/85
HSC-B SH 16	16	M16	≥ 240	≥ 240	≥ 50	≥ 38	≥ 12	≥ 12	≥ 10	≥ 6	C20/25 – C70/85
HSC-B SH 20	20	M20	≥ 300	≥ 300	≥ 63	≥ 48	≥ 16	≥ 12	≥ 12	≥ 8	C20/25 – C35/45
			≥ 240	≥ 240	≥ 63	≥ 48	≥ 16	≥ 12	≥ 12	≥ 8	C40/50 – C70/85
HSC-B SH 25	25	M27	≥ 400	≥ 300	≥ 86	≥ 66	≥ 20	≥ 20	≥ 20	≥ 12	C20/25
			≥ 350	≥ 300	≥ 86	≥ 66	≥ 20	≥ 20	≥ 20	≥ 12	C25/30 – C30/37
			≥ 300	≥ 300	≥ 86	≥ 66	≥ 20	≥ 20	≥ 20	≥ 12	C35/45 – C70/85

Halfen Stud Connector

Intended use
Installation regulations for bolted end-plate connections,
structural steelwork socket bar with anchor head

Annex B12

Table B8: Coefficient of friction between end-plate and connection plane caused by bending moment and/or compression force on the fixture

Type of connection joint or class of friction surface	μ_{inf} [1)]	μ_{sup}
Steel – to – Steel [2)]	0,1	0,2
Steel – to – concrete [3)]	0,2	0,45

1) only applies if suitable measures are taken on site to ensure that the friction on the contact surfaces can be activated as planned, otherwise $\mu_{inf} = 0$
2) Fixture braced against mounting template made of steel plate
3) Fixture braced against surface of concrete element

Bolted end-plate connections at component edge

For bolted end-plate connections arranged close to the edge and loaded perpendicular to the edge by a shear force, a minimum edge distance of $15 \cdot l_{socket}$ for the end-plate in the direction of the shear load applies.

If the edge distance is $< 15 \cdot l_{socket}$, the connected shear force shall be taken up by a supplementary reinforcement in the shape of stirrups, links or loops, it should enclose the shaft of the socket bar and be positioned as closely as possible to the fixture as a direct force transmission from the structural steelwork socket bars to the supporting reinforcement is assumed. The tensile force in the supplementary reinforcement should be anchored above the connection plane or rather the upper cross-section area with a respective lap splice to the element reinforcement in accordance with EN 1992-1-1. Otherwise, the load transfer from the supplementary reinforcement to the structural reinforced component shall be verified with a suitable model, e.g. a simplified strut and tie model. Transverse reinforcement is to be placed at the anchor heads close to the edge. The existing component reinforcement may be counted as edge reinforcement.

Halfen Stud Connector

Intended use
Installation regulations for bolted end-plate connections, structural steelwork socket bar with anchor head

Annex B13

Structural steelwork socket bars with bend type “HSC-B SB” for bolted end-plate connections

- Anchoring of the tensile force on the opposite column side by transfer to the element reinforcement with a corresponding lap in accordance with EN 1992-1-1
- Coefficient of friction between end-plate and connection plane according to Annex B13, Table B8
- Alternative double-sided bolted end-plate connection using double socket rebar type “HSC-B SD” possible

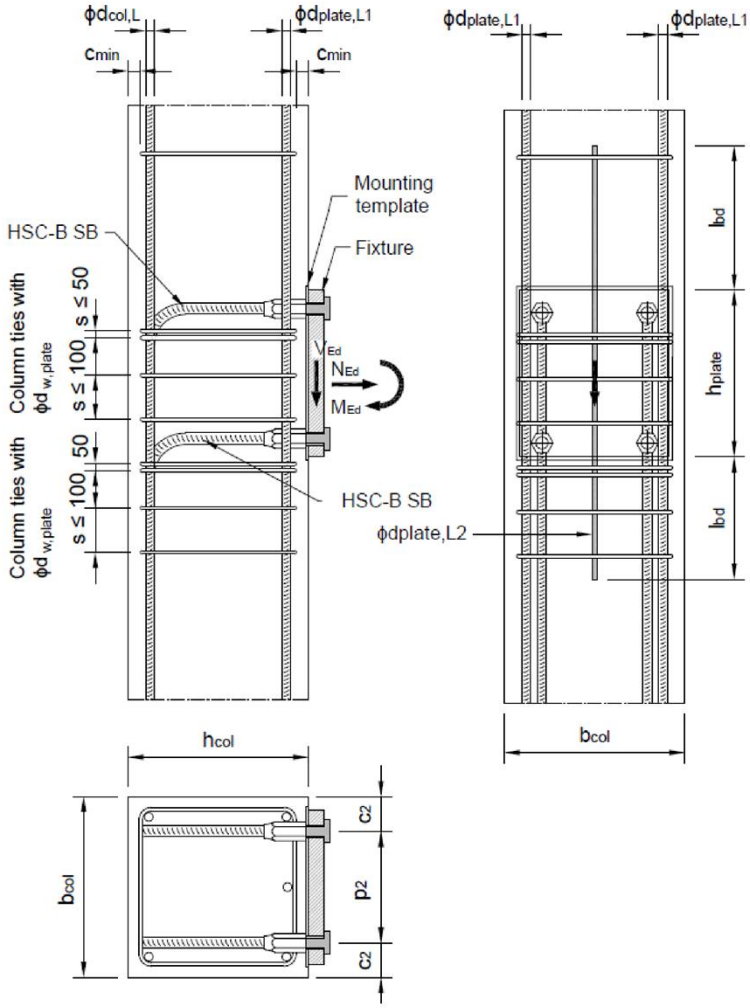


Fig. B28: Dimensioning and detailing of bolted end-plate connections, anchorage of structural steelwork socket bars by lapping of bars

Table B9: Dimension of bolted end-plate connections at reinforced concrete structures (rebars with bend)

Type	ϕd_a	d_{th}	c_2	p_2	$\phi d_{col,L}$	$\phi d_{plate,L1}$	$\phi d_{plate,L2}$	$\phi d_{w,plate}$
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
HSC-B SB 12	12	M12	≥ 40	≥ 30	≥ 12	≥ 12	≥ 10	≥ 6
HSC-B SB 14	14	M14	≥ 46	≥ 35	≥ 12	≥ 12	≥ 10	≥ 6
HSC-B SB 16	16	M16	≥ 50	≥ 38	≥ 12	≥ 12	≥ 10	≥ 6
HSC-B SB 20	20	M20	≥ 63	≥ 48	≥ 12	≥ 12	≥ 12	≥ 8
HSC-B SB 25	25	M27	≥ 86	≥ 66	≥ 20	≥ 20	≥ 20	≥ 12

Halfen Stud Connector

Intended use
Installation regulations for bolted end-plate connections, structural steelwork socket bar with bend

Annex B14

C.1 Essential characteristics of headed rebars "Halfen Stud Connector HSC"

Table C1: Essential characteristics of headed rebars according to Annex A8, Table A3

HSC		ϕd_a [1]	[mm]	12	14	16	20	25
Resistance to static or quasi-static loading	Failure of rebar	$f_{u,min,bar,outside}$ [2]	[N/mm²]	540				
	Failure inside mechanical splice length of reinforcing steel bars [3]	$f_{u,min,bar,inside}$ [4]	[N/mm²]	540				
		$f_{u,min,bar,socket}$ [5]	[N/mm²]	650				
		$A_{gt,act}$	[%]	3,0				
	Coefficient for accounting the anchorage effect of stud connector	k_6	[-]	1,55				
	Coefficient for accounting the effective joint shear reinforcement	k_7	[-]	0,475				
Resistance to fatigue loading [6]	Characteristic fatigue strength for $N = 2 \cdot 10^6$ load cycles	$\Delta\sigma_{Rsk}$	[N/mm²]	80				70
	Stress exponents of S-N-curve for N load cycles	k_1 $N < 2 \cdot 10^6$	[-]	3,5				3,5
		k_1 $2 \cdot 10^6 \leq N \leq 10^7$	[-]	3,0				3,0
		k_2 $N > 10^7$	[-]	5,0				5,0

[1] B500B, ϕd_a = 12 and 14mm alternative in B500 NR

[2] $f_{u,min,bar,outside} = 1{,}08 \cdot R_{e,nom}$ (in case of bar failure outside splice length, failure of anchor head or failure of flash welding, if relevant)

[3] only for type "HSC-S", "HSC-SD" and "HSC-A"

[4] $f_{u,min,bar,inside} = 1{,}08 \cdot R_{e,nom}$ (in case of bar failure inside splice length)

[5] $f_{u,min,bar,socket} = 1{,}3 \cdot R_{e,nom}$ (in case of coupler failure)

[6] Fatigue strength $\Delta\sigma_{Rsk}$: S-N-curve with specific k_1 and k_2

Halfen Stud Connector	Annex C1
Performance Essential characteristics of "Halfen Stud Connector HSC"	

C.2 Essential characteristics of structural steelwork socket bars "Halfen Stud Connector HSC-B"

Table C2: Essential characteristics of structural steelwork socket bars according to Annex A8, Table A4

HSC-B									
		ϕd_a [1]		[mm]	12	14	16	20	25
		d_{th}		[mm]	M12	M14	M16	M20	M27
Resistance to static or quasi-static loading	Failure of rebar	$f_{u,min,bar,outside}$ [2]		[N/mm²]	540				
	Failure inside splice length of bar-structural steelwork socket	$f_{u,min,bar,inside}$ [3]		[N/mm²]	540				
		$f_{u,min,bar,socket}$ [4]		[N/mm²]	650				
		$A_{gt,act}$		[%]	3,0				
	Steel failure of structural steelwork socket	N-V interaction condition		[-]	see in Annex C3, Diagram C1				
	Coefficient for accounting the local concrete shear resistance	k_8		[-]	1,44				
	Coefficient for accounting the effective shear resistance on concrete edge	k_9		[-]	15				
Resistance to fatigue loading [5]	Characteristic fatigue strength for $N = 2 \cdot 10^6$ load cycles	$\Delta\sigma_{Rsk}$		[N/mm²]	80				70
	Stress exponents of S-N-curve for N load cycles	k_1	$N < 2 \cdot 10^6$	[-]	3,5				3,5
			$2 \cdot 10^6 \leq N \leq 10^7$	[-]	3,0				3,0
		k_2	$N > 10^7$	[-]	5,0				5,0

[1] B500B, ϕd_a = 12 and 14mm alternative in B500 NR

[2] $f_{u,min,bar,outside} = 1{,}08 \cdot R_{e,nom}$ (in case of bar failure outside splice length, failure of anchor head or failure of flash welding, if relevant)

[3] $f_{u,min,bar,inside} = 1{,}08 \cdot R_{e,nom}$ (in case of bar failure inside splice length)

[4] $f_{u,min,bar,socket} = 1{,}3 \cdot R_{e,nom}$ (in case of structural steelwork socket failure)

[5] Fatigue strength $\Delta\sigma_{Rsk}$: S-N-curve with specific k_1 and k_2

Halfen Stud Connector	Annex C2
Performance Essential characteristics of "Halfen Stud Connector HSC-B"	

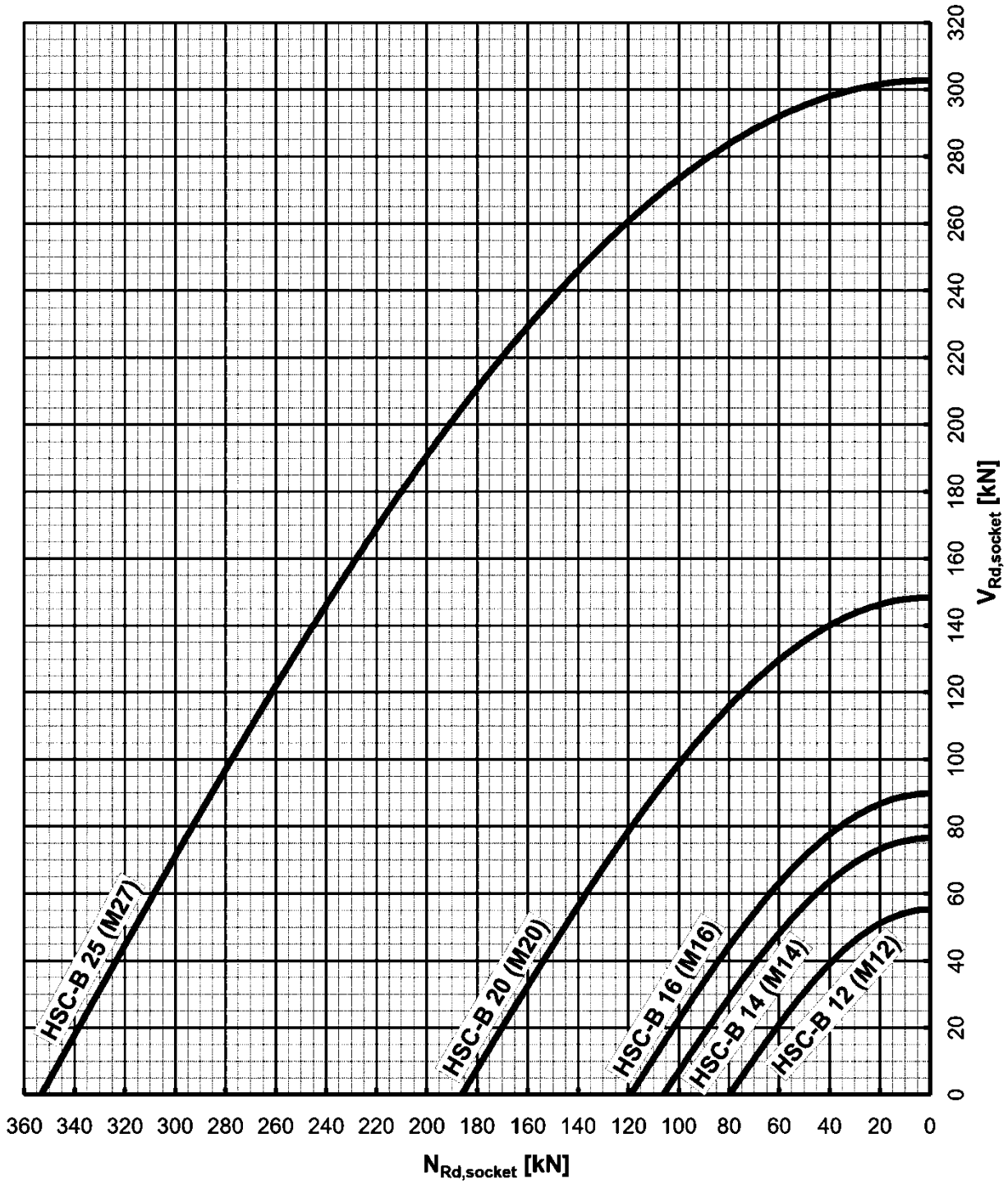
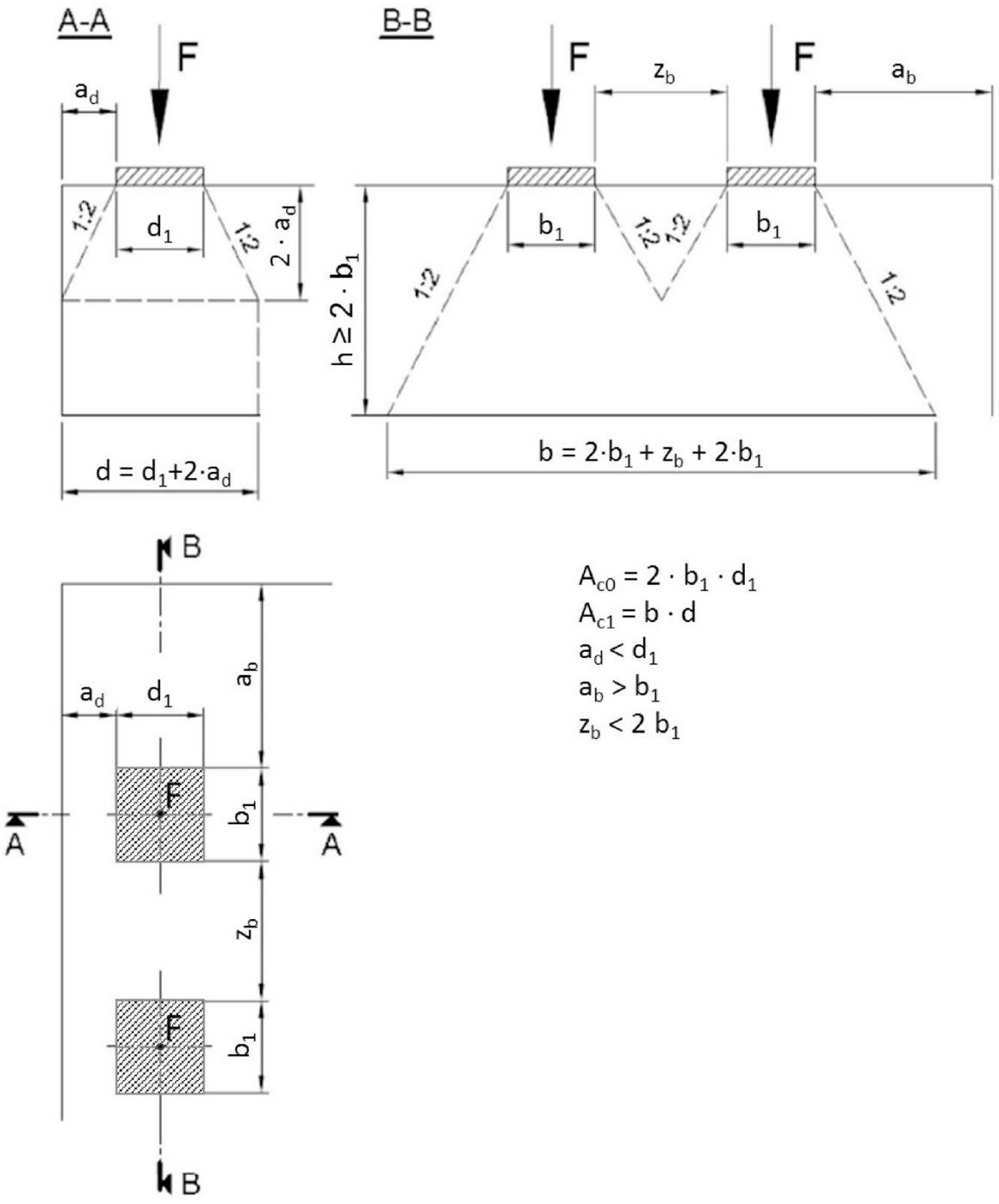


Diagram C1: N-V-interaction resistance diagram with steel failure of a structural steelwork socket under any load case. The verification is considered to be fulfilled if the actions are within the permissible range. The permissible range is enclosed in each case by the corresponding limit curve and the coordinate axes. (Essential characteristics for the design)

Halfen Stud Connector	Annex C3
Performance Essential characteristics of "Halfen Stud Connector HSC-B"	

D.1 Design distribitution for partially loaded areas



$A_{c0} = 2 \cdot b_1 \cdot d_1$
$A_{c1} = b \cdot d$
$a_d < d_1$
$a_b > b_1$
$z_b < 2\ b_1$

Fig. D1: Determination of the maximum design distribitution area A_{c1} with a similar shape to A_{c0}

Halfen Stud Connector	
Informative Design distribution for partially loaded areas	Annex D1